

Aug. 3, 1948.

B. D. WILLIS

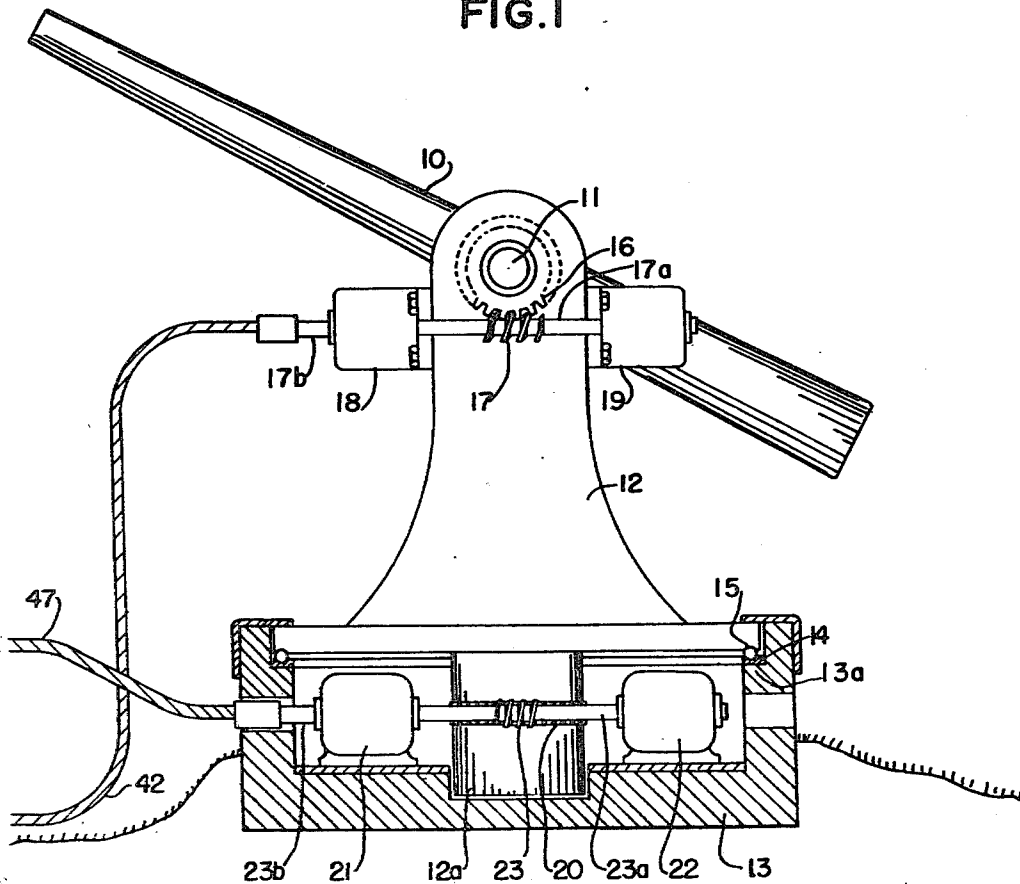
2,446,316

GUN SIGHTING AND TRAINING APPARATUS

Filed Sept. 14, 1942

4 Sheets-Sheet 1

FIG. 1



INVENTOR.
BERNARD D WILLIS, DECEASED
BY Wm. WALTER OWEN. EXECUTOR
Davis, Lindsey, Smith & Shotts
ATTORNEYS

Aug. 3, 1948.

B. D. WILLIS

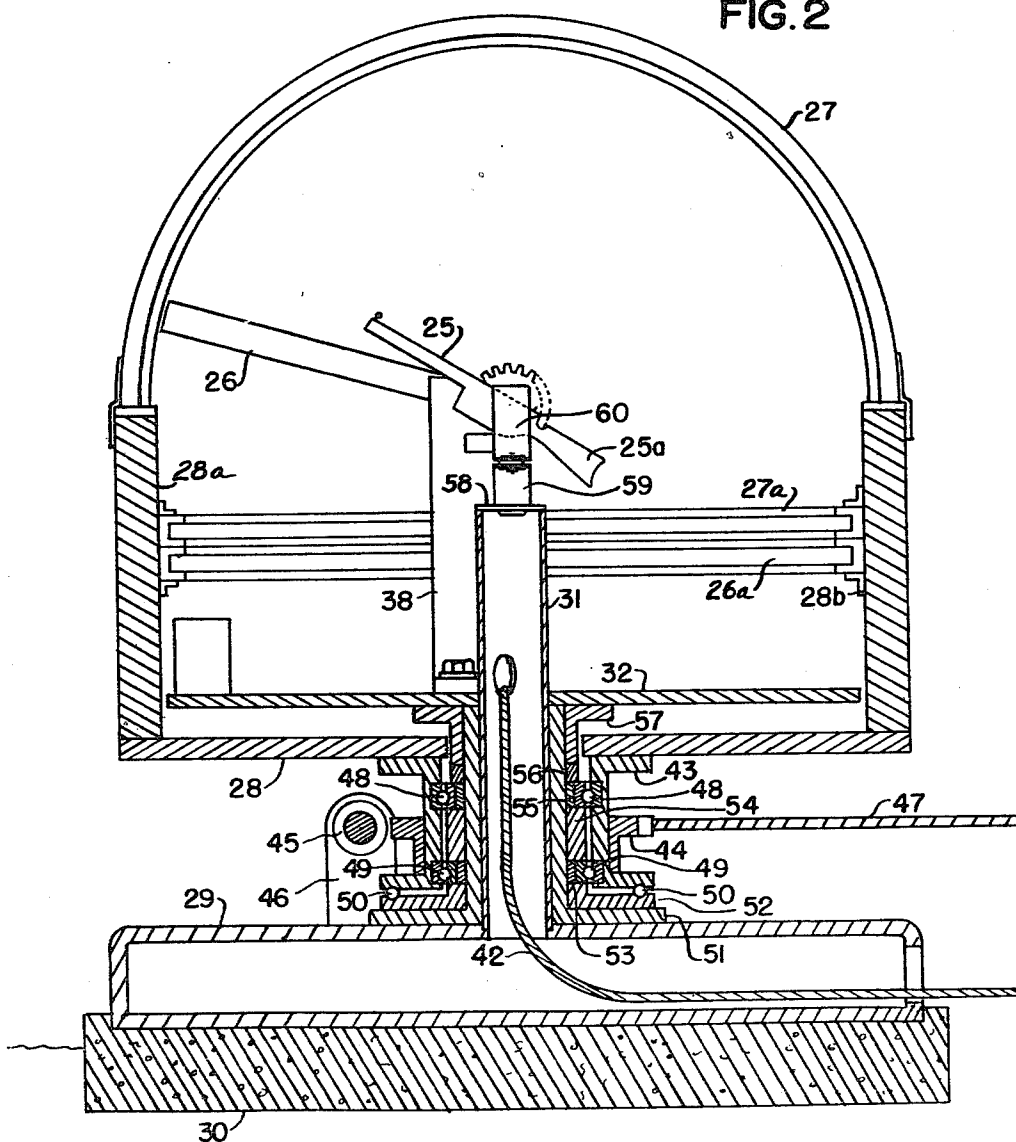
2,446,316

GUN SIGHTING AND TRAINING APPARATUS

Filed Sept. 14, 1942

4 Sheets-Sheet 2

FIG. 2



INVENTOR.
BERNARD D. WILLIS, DECEASED
BY W^m WALTER OWEN. EXECUTOR
Davis, Lindsey, Smith & Shonto
ATTORNEYS

Aug. 3, 1948.

B. D. WILLIS

2,446,316

GUN SIGHTING AND TRAINING APPARATUS

Filed Sept. 14, 1942

4 Sheets-Sheet 3

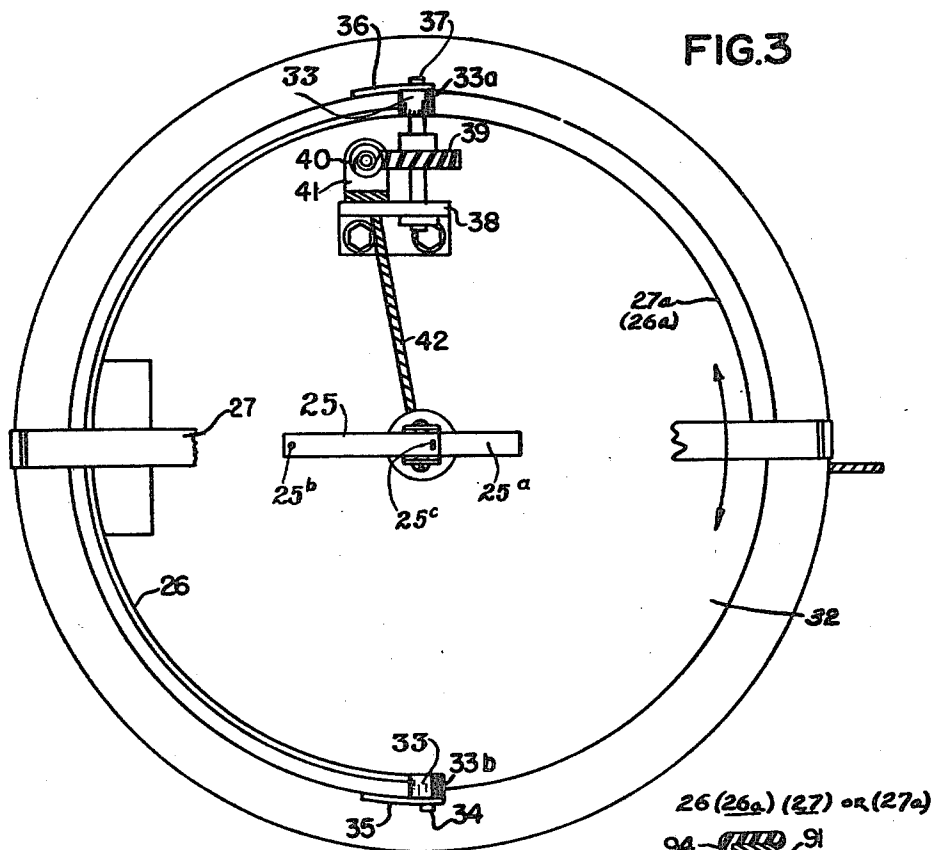


FIG. 3

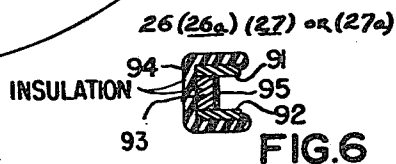


FIG. 6

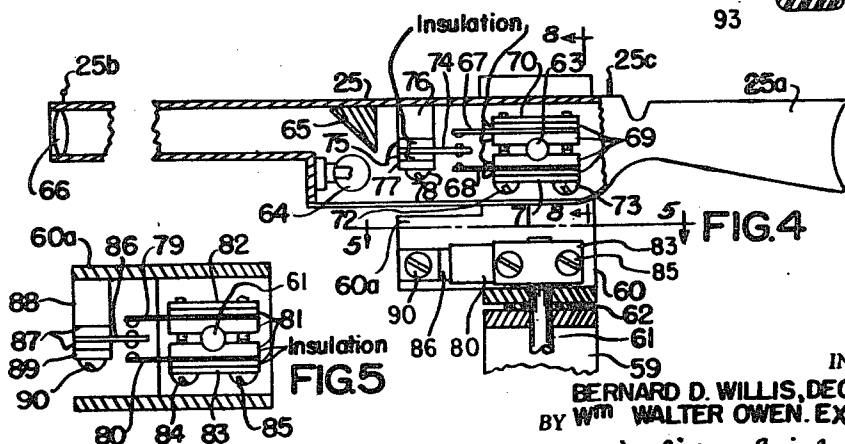


FIG. 4

FIG. 5

INVENTOR.
BERNARD D. WILLIS, DECEASED
BY W^M WALTER OWEN, EXECUTOR
Davis, Lindsay, Smith & Shonto
ATTORNEYS

Aug. 3, 1948.

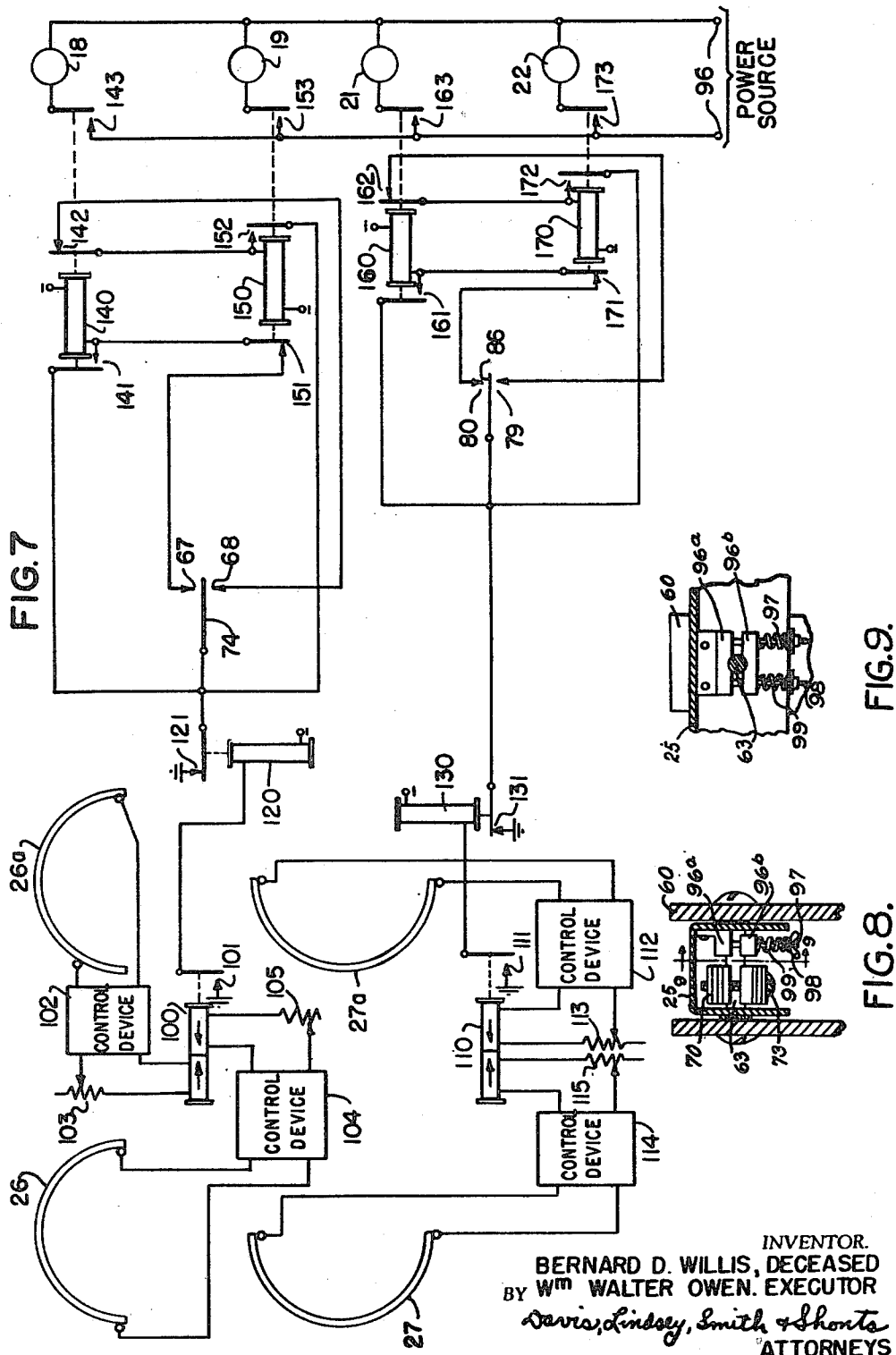
B. D. WILLIS

2,446,316

GUN SIGHTING AND TRAINING APPARATUS

Filed Sept. 14, 1942

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,446,316

GUN SIGHTING AND TRAINING APPARATUS

Bernard D. Willis, deceased, late of Oak Park, Ill.,
by Wm. Walter Owen, executor, Elgin, Ill., as-
signor to Automatic Electric Laboratories, Inc.,
a corporation of Delaware

Application September 14, 1942, Serial No. 458,295

16 Claims. (Cl. 89—41)

1

2

The present invention relates to fire control apparatus for ordnance pieces and, more particularly, to improvements in apparatus for controlling the pointing of a gun from a remote point.

It is an object of the present invention to provide improved fire control apparatus which is simple in arrangement, easy to operate, and positive and reliable in its operation.

It is another object of the invention to provide improved apparatus of the character described which is so arranged that the only operation required on the part of an operator to bring the gun to bear on a target is that of manually manipulating a light sighting piece.

According to another object of the invention, provisions are made in the apparatus for causing the gun to follow the movement of the sighting piece and for automatically stopping movement of the gun when it is brought to bear in the direction established by the line of sight of the sighting piece.

In accordance with another object of the invention, movement of the gun is automatically initiated in response to movement of the sighting piece from one position to a new position.

According to a further object of the invention, the sighting piece is equipped to project a light beam along the line of sight thereof and light sensitive exploring elements arranged to be controlled by the light beam are utilized to stop the movement of the gun when it is brought to bear in the direction established by the sighting piece.

According to still another object of the invention, provisions are made in the apparatus for preventing changes in the temperature of the exploring elements and changes in the intensity of the light surrounding these elements from falsely causing movement of the gun.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification taken in connection with the accompanying drawings in which Fig. 1 illustrates in partial schematic form the mechanism of a gun which may be controlled by apparatus constructed in accordance with the present invention; Fig. 2 is a side view partially in section of the control apparatus provided to control the gun shown in Fig. 1; Fig. 3

is an elevational view of the apparatus shown in Fig. 2; Fig. 4 is a detailed sectional view of the sighting piece 25; Fig. 5 is a detailed sectional view taken on the line 5—5 of Fig. 4; Fig. 6 is a cross-sectional view of the exploring band 26 or 27 and the balancing band 26a or 27a; Fig. 7 is a circuit diagram showing how the control apparatus and the driving means for the gun are electrically interconnected; Fig. 8 is a detailed sectional view taken on the line 8—8 of Fig. 4; and Fig. 9 is a sectional view taken on the line 9—9 of Fig. 8.

Referring now more particularly to Fig. 1 of the drawings, the gun there illustrated may be of the heavy type now commonly used in aircraft defense installations. Briefly considered, the gun comprises a barrel 10 which is mounted for rotation with a shaft 11 journaled in the upstanding ends of a pedestal 12. This pedestal is supported for rotation on a heavy cup-shaped base 13 which may be fixedly mounted in a suitable gun emplacement. More specifically, the upper, inner edge of the base 13 is cut away to provide a shoulder 13a which carries a ball race 14. Anti-friction ball bearings 15 held between this race and a ball receiving channel cut in the underside of the pedestal 12 are provided to permit the pedestal to be easily rotated relative to the base 13. Similar anti-friction bearings may be used between the shaft 11 and the upstanding ends of the pedestal 12 to facilitate rotation of the gun barrel 10 in elevation with respect to the pedestal. For the purpose of rotating the shaft 11, thereby to change the angle of elevation of the gun barrel 10, a driving mechanism is provided which comprises a worm gear 16 rigidly mounted upon one end of the shaft 11, a driving worm 17 and a pair of alternating current motors 18 and 19 which are suitably mounted upon opposite sides of the pedestal 12. Preferably, the rotors of the two motors 18 and 19 are both carried by the single worm shaft 17a and this shaft is provided with an extension 17b through which an auxiliary drive connection may be made in the manner pointed out below. For the purpose of imparting rotary movement to the pedestal 12, thereby to change the traverse of the gun barrel 10, the pedestal is provided with a downwardly extending cylindrical portion 12a having a worm gear 20 suitably mounted thereon.

3

Rotary movement may be imparted to the gear 20 by means of two additional alternating current motors 21 and 22 which are suitably mounted within the cup-shaped recess of the base 13. The rotors of these two motors are mounted upon a worm shaft 23a which carries a worm 23 that meshes with the worm gear 20 and is provided with an extension 23b. From the above explanation it will be understood that by selective energization of the two motors 18 and 19 the gun barrel 10 may be rotated in either direction relative to the axis of the shaft 11. More specifically, these motors are arranged to drive the worm shaft 17a in opposite directions so that if the motor 18, for example, is energized, the gun barrel 10 is pivoted in a clockwise direction relative to the axis of the shaft 11 to increase the elevation thereof, whereas if the opposite motor 19 is energized, the gun barrel is pivoted in the reverse direction to decrease the angle of elevation thereof. It will also be understood that by selective energization of the two motors 21 and 22 the pedestal 12 may be rotated in either direction about its axis of rotation to alter the traverse of the gun. To this end, the motor 21 may be arranged to rotate the pedestal 12 in a counterclockwise direction relative to its axis while the motor 22 is arranged to rotate the pedestal in a clockwise direction about its axis. Since the breech and firing mechanisms of the gun form no part of the present invention, the details of these mechanisms have not been shown. It is pointed out, however, that the gun is equipped with an electromagnetically actuated firing mechanism such that the firing as well as the pointing of the gun may be controlled from a remote point.

Referring now more particularly to Figs. 2 and 3 of the drawings, the apparatus there illustrated is provided for controlling the elevation and traverse of the gun shown in Fig. 1 of the drawings and may be located at any desired point remote from the gun emplacement. Generally considered, this apparatus comprises a sighting piece 25, an elevation finding loop or exploring band 26 and a direction or traverse finding loop or exploring band 27. More specifically, the direction finding loop 27 is fixedly mounted upon the two upstanding columns 28a and 28b of a frame 28 which is supported for rotation on a base 29. This base may, in turn, be supported in a concrete supporting structure 30. The base 29 is provided with a hollow centrally disposed pedestal 31 and also supports an operator's platform 32. This platform has mounted thereon, on either side of the pedestal 31, two bracket pieces 33 which, at their upper ends, pivotally support the ends of the elevation finding loop 26. More specifically, the bracket pieces 33a and 33b are rounded at their upper ends to provide bearing surfaces for the adjacent inwardly curved end surfaces of the loop 26. The bracket piece 33b is provided with a pivot pin 34 which extends through an opening provided in an assembly plate 35 secured to the lower end of the loop 26 as viewed in Fig. 3 of the drawings. The other end of this loop carries an assembly plate 36 which is rigidly connected to a shaft 37 journaled in the upper end of the bracket piece 33a and in a third bracket piece 38 also carried by the platform 32.

For the purpose of imparting rotary movement to the shaft 37, and through this shaft to the elevation finding loop 26, a worm gear 39 is rigidly mounted upon the shaft 37. This gear meshes with a driving worm 40 which is suitably jour-

4

naled in a U-shaped bracket 41 mounted upon the upper end of the bracket piece 38, and is connected by means of a flexible shaft 42 with the motor shaft extension 17b of the worm shaft 17a. By virtue of this arrangement, a substantially rigid drive connection is provided between the worm shaft 17a and the elevation finding loop 26. In the assembly of this drive connection the parts are so arranged and adjusted that the angle of elevation between the elevation finding loop 26 and a true horizontal plane is exactly the same as the angle of elevation between the gun 10 and a true horizontal plane. Moreover, the driving ratio between the worm 17 and the shaft 11 is exactly equal to that between worm 40 and the shaft 37, whereby the angular positions of the gun barrel 10 and the loop 26 with respect to true horizontal are maintained exactly the same during movement of the gun barrel 10 to bear on a selected target.

As indicated above, the direction finding loop 27 is carried by a frame 28 which is rotatable about the central pedestal 31 of the base 29. More specifically, this frame, at the central portion thereof, is supported upon a flanged sleeve 43 which carries a worm gear 44 intermediate the two flanges thereof. This gear meshes with a driving worm 45 suitably journaled in a bracket piece 46 carried by the base 29, and is connected by means of a flexible shaft 47 to the shaft extension 23b of the rotor shaft 23a. As thus arranged, a positive drive connection is provided between the rotor shaft 23a and the frame 28 upon which the direction finding loop 27 is mounted. In the assembly of the apparatus the parts of this drive connection are so arranged and adjusted that the vertical plane cutting the direction finding loop 27 is exactly parallel with the vertical plane cutting the gun barrel 10. Moreover, the driving ratio between the worm 23 and the gear 20 is exactly the same as the drive ratio between the worm 45 and the gear 44, whereby the parallel vertical relationship between the direction finding loop 27 and the gun barrel 10 is maintained during operation of either of the motors 21 and 22 to drive the pedestal 12 to a new traverse position.

In order to render the frame 28 readily rotatable about the pedestal 31, suitable anti-friction bearings 48, 49 and 50 are provided between the sleeve 43 and the stationary parts of the structure. More specifically, the central pedestal 31 has telescoped thereover a flanged sleeve 51 which bears against the upper side of the base 29. The flanged portion of this sleeve carries a bearing ring 52 having a ball race therein in which the anti-friction balls 50 are disposed. This bearing ring also supports a series of assembly and spacing rings 53, 54, 55, 56 and 57 which are telescoped over the sleeve 51. The last of these series of rings is flanged outwardly at its upper end to provide an extended surface for supporting the platform 32.

The sighting piece 25 is supported upon the top supporting plate 58 of the centrally disposed pedestal 31. More specifically, the supporting plate 58 carries a U-shaped bracket piece 59 having its legs extending downwardly, and a second U-shaped bracket 60 is pivotally mounted upon the bracket 59 with its legs extending in a vertical direction to provide a support for the sighting piece 25. As best shown in Fig. 4 of the drawings, a shaft 61 extending vertically through registering openings in the plate 58 and the base portions of the two U-shaped members 59 of the

5

bracket 60 is utilized to provide a pivot point about which the bracket 60 may be rotated. A suitable anti-friction washer 62 is provided between the adjacent surfaces of the two bracket pieces 59 and 60 to facilitate rotation of the bracket 60 relative to the bracket 59 in a horizontal plane. The sighting piece 25, which is shaped as a shotgun having a stock 25a, is mounted for rotation about a shaft 63 which is suitably journaled in the oppositely disposed legs of the bracket 60. The sighting piece is hollow and preferably is formed of a light metal, such as aluminum. Its oppositely disposed vertically extending side walls are journaled on the shaft 63 so that the entire piece is readily rotatable about this shaft. In order to bring the sighting piece 25 to bear in a desired direction and, more particularly, to point this piece at a target, it is equipped at the front and rear ends of the barrel portion thereof with front and rear sights 25b and 25c, respectively.

An optical system is mounted within the sighting piece 25 for projecting a beam of light along the line of sight thereof. This optical system comprises a light source in the form of an incandescent lamp 64, a deflecting mirror 65 for transmitting the light produced by the lamp 64 along the barrel of the sighting piece, and a converging lens 66 for controlling the width of the light beam projected from the front end of the sighting piece. The three enumerated elements may be mounted within the sighting piece 25 in the illustrated positions thereof in any suitable manner.

For the purpose of controlling the driving motors 10, 19, 21 and 22 in the manner more fully described below, two circuit control devices are provided which are respectively controlled in accordance with the vertical and horizontal rotation of the sighting piece 25. The first of these devices comprises a pair of contact elements 67 and 68 which are assembled between insulating strips 69 and are rigidly mounted for rotation with the shaft 63 by means of a clamping assembly which includes two clamping plates 70 and 71 and a pair of clamping screws 72 and 73. The two contact elements 67 and 68 are arranged to cooperate with a third contact element 74 which is assembled between two insulating pieces 75 and is mounted upon the upper under surface of the sighting piece 25 by means of a supporting column 76, a clamping ring 77 and an assembly screw 78. As thus arranged, when the sighting piece 25 is manually rotated initially in a clockwise direction about the shaft 63 to increase the angle of elevation thereof, the stiff contact element 74 is moved to bring the contact carried by the free end thereof into engagement with the contact carried by the free end of the contact element 67. During such movement of the sighting piece 25 the shaft 63 does not rotate. When, however, the adjacent contacts carried by the two contact elements 74 and 67 are engaged, the two contact elements 67 and 68, together with the shaft 63, are thereby constrained to rotate with the sighting piece 25 for a purpose hereinafter explained. Conversely, when the sighting piece 25 is pivoted in a counterclockwise direction about the shaft 63 to decrease the angle of elevation thereof, the lower contact carried by the element 74 is moved to engage the contact carried by the element 68, after which the sighting piece 25 and the shaft 63 are rotated in unison for a purpose hereinafter explained. In this regard it is noted that suitable spring-biased friction means

6

may be provided between the shaft 63 and the legs of the bracket 60 to insure that the shaft 63 will not be rotated until the contact carried by the element 74 is moved to engage one of the contacts carried by the associated contact elements 67 and 68. This spring-biased friction means may have various forms but may conveniently be constructed as shown in Figs. 8 and 9 where the shaft 63, shown as being journaled in the side legs of the bracket 60 and in the side walls of the sighting piece 25, has applied thereto a friction brake comprising two brake shoes 96a and 96b, the former of which is secured to one of the side walls of the sighting piece on the inner side thereof. These shoe members are connected by bolts 97 and wing nuts 98 and a spring 99 is mounted on each bolt between the lower floating shoe 96b and the wing nut so that by adjusting these nuts the normal compression of these springs 99 may be adjusted to produce the desired frictional resistance to the rotation of the shaft 63.

The other circuit control device, i. e., that which responds to rotation of the sighting piece 25 in the horizontal plane, is arranged to be controlled by relative movement between the bracket 60 and the shaft 61. This device comprises a pair of contact elements 79 and 80 which are assembled between the insulating strips 81 and are rigidly mounted upon the upper end of the shaft 61 by means of a clamping assembly which comprises the two clamping plates 82 and 83 and the assembly screws 84 and 85. The two contact elements 79 and 80 are arranged to cooperate with a third contact element 86 which is clamped between the two insulating strips 87 and is mounted upon an outwardly projecting portion 80a of the bracket 60 by a mounting assembly which includes the column 88, a clamping ring 89 and an assembly screw 90. As thus arranged, the contact carried by the free end of the contact element 86 is moved to engage the contact carried by the free end of the element 79 during preliminary rotation of the sighting piece 25 about the shaft 61. After these two contacts are engaged, the shaft 61 is rotated with and by the sighting piece 25. Conversely, if the sighting piece is rotated in a counterclockwise direction about the shaft 61, the contact carried by the element 86 is moved to engage the contact carried by the element 80, after which the sighting piece and the shaft 61 are thereby constrained to rotate in unison. Here again it is pointed out that suitable spring-biased friction means, similar to that shown in Figs. 8 and 9, may be used to insure relative rotation between the brackets 60 and 59 until such time as the contact carried by the contact element 86 is moved to engage the contact carried by one of the two coacting elements 79 and 80.

Further to consider the arrangement of the control apparatus as shown in Figs. 2 and 3 of the drawings, it may be pointed out that the light beam as projected along the line of sight of the sighting piece 25 by the optical system mounted within this sighting piece is utilized as a vehicle to arrest the traverse and elevational movements of the gun barrel 10 when this barrel is brought to bear in the direction established by the line of sight of the sighting piece. To this end, the exploring bands or loops 26 and 27 are constructed to form light sensitive elements. Each of these bands is shaped to form an exact semi-circle, the true center of which is coincident with the corresponding center of rotation of the sighting piece 25. Thus the center of the elevation finding band

26 coincides with the point about which the sighting piece 25 may be rotated in a horizontal direction or a vertical azimuth direction. The center of the semi-circular direction finding band 27 also exactly coincides with this point.

Preferably, each of the two bands 26 and 27 is constructed in the manner shown in Fig. 6 of the drawings. Briefly considered, this construction comprises two semi-circular strips 91 and 92 formed of copper or other conductive material, which are held in spaced apart relationship by means of a semi-circular spacing element 93 formed of suitable insulating material. The three pieces 91, 92 and 93 are held in assembled relationship by means of an assembly ferrule 94 which may be formed of Bakelite or other mouldable insulating material. The inner surface of the spacing element 93 is provided with a coating or layer of light sensitive material 95, such, for example, as selenium. As thus constructed, it will be understood that the electrical resistance between the two strips 91 and 92 is a function of the intensity of light impinging upon the light sensitive layer 95. This resistance is sharply decreased in response to a change in the intensity of the light striking the light sensitive layer 95 at any point therealong. Thus if the light beam projected along the line of sight of the sighting piece 25 strikes a segment of the layer 95, the electrical resistance between the two conductors 91 and 92 is rapidly and sharply lowered.

In utilizing the sighting piece 25 and the two exploring bands 26 and 27 to control the operation of the four motors 18, 19, 21 and 22, the circuit network shown in Fig. 7 of the drawings may be employed. In this network the four motors are shown as being connected for energization from a suitable source of alternating current indicated by the bracketed terminals 96. The four motors are respectively arranged for energization under the control of four relays 140, 150, 160 and 170. These relays, in turn, are arranged to be controlled by the contact elements 67, 68, 74, 79, 80 and 86 of the two circuit controlling devices and by a pair of stop relays 120 and 130. Bridge-type of control circuits are utilized for controlling the energization of the two stop relays 120 and 130. More specifically, the exploring band 26 is arranged to control the energization of the stop relay 120. To this end, the electrical resistance between the two conductive strips of the band 26 is connected through the electronic control device 104 to control the energization of the right-hand winding of a differentially wound relay 100. The other winding of this relay is arranged to be energized in the output circuit of a second electronic control device 102 having its input circuit connected to include the resistance between the conductive elements of a balancing band 26a hereinafter more fully described. Adjustable resistors 103 and 105 are respectively provided in the circuits through which the two windings of the relay are energized, in order normally to equalize the currents traversing these two windings. In a similar manner a differentially wound relay 110 is provided directly to control the energization of the stop relay 130. The energization of the left-hand winding of this relay is arranged to be controlled through an electronic control device 114 in accordance with the resistance between the conductive strips of the exploring band 27, while the opposite winding of this relay is arranged to be controlled through a fourth electronic control device 112

in accordance with the resistance between the conductive strips of a balancing band 27a. Adjustable resistors 113 and 115 are respectively included in the circuits for energizing the windings of the relay 110 in order that these windings may normally be energized by currents of the same magnitude.

At this point it is noted that the construction and characteristics of two balancing bands 26a and 27a located in the vicinity of the bands 26 and 27 exactly duplicate the construction and characteristics of the bands 26 and 27, respectively. Moreover, these two balancing bands are exposed to the same ambient temperature and light conditions as the exploring bands 26 and 27 but are not exposed to the light beam emitted by the sighting piece. While in the illustrated embodiment of the invention the balancing bands 26a and 27a are shown rigidly supported in parallel relationship in a horizontal plane by the two upstanding columns 28a and 28b, it should be understood that the balancing bands may be supported in any manner so long as they are exposed to substantially the same ambient temperature and light conditions as the movable exploring bands 26 and 27. By virtue of this arrangement, changes in the ambient temperature and light conditions to which the exploring bands 26 and 27 are subjected are prevented from producing a false response of the differential relays 100 and 110. Thus, if the resistance between the conductive strips of the band 26, for example, is decreased, due to a change in the temperature or the intensity of the light other than the light from the sighting piece 25 impinging upon the light sensitive surface thereof, thereby to produce an increase in the current flow through the right winding of the relay 100, the resistance between the conductive strips of the balancing band 26a is correspondingly decreased to produce a corresponding increase in the current flow through the left winding of the relay 100. The relay is thus prevented from falsely operating. The same type of balancing action is produced by the balancing band 27a associated with the exploring band 27.

Current for energizing the relays 120, 130, 140, 150, 160 and 170, and for controlling the thermionic elements of the four control devices 102, 104, 112 and 114 may be supplied from any suitable direct current source of the proper potential. In the interests of facilitating a description of the circuits involved, this source has not been shown. It will be understood, however, that the positive terminal of the source is connected to each of the points of the illustrated circuit indicated by the ground symbol and that the negative terminal of the source is connected to each of the relay winding terminals identified by the negative polarity sign.

In considering the operation of the apparatus described above, it may be assumed that the sighting piece 25 is pointing in a particular direction, that the lamp 64 is energized to project a light beam along the line of sight of the sighting piece, and that the exploring bands 26 and 27 both occupy positions wherein the light sensitive layers thereof are intersected by the light beam. In this regard it is noted that the cross-sectional area of the light beam as measured at the point of intersection with the overlapped portions of the two bands 26 and 27 is sufficient to permit segments of both bands to be cut by the beam. The correct cross-sectional dimensions of the light beam at this point may be de-

terminated by using a converging lens 88 having the proper optical properties.

Under the conditions stated, the resistance between the conductive strips of the exploring band 26 is considerably less than the resistance between the conductive strips of the balancing band 26a, which is not exposed to the light beam. Accordingly, the right winding of the differential relay 100 is energized by a current of substantially greater magnitude than that traversing the left winding of this relay, and the relay occupies its operated position. With this relay operated, an obvious circuit is completed through the contacts 101 for energizing the stop relay 120. With the relay 120 in its operated position, the operating circuits for the two relays 140 and 150 are held open at the contacts 121, the latter contacts being normally biased into closed circuit position. In a similar manner, with the light sensitive layer of the exploring band 27 exposed to the light beam produced by the lamp 64 and projected along the line of sight of the sighting piece 25, the resistance between the conductive strips of the band is substantially lower than the resistance between the conductive strips of the balancing band 27a. Accordingly, the left winding of the relay 110 is energized by a current of substantially greater magnitude than that traversing the right winding of this relay, and the relay is operated. With the relay 110 in its operated position, an obvious circuit is completed through the contacts 111 for energizing the stop relay 130. With the latter relay operated the operating circuits for the two relays 160 and 170 are held open at the contacts 131, the latter contacts being normally biased into closed circuit position.

If with the four relays 100, 110, 120 and 130 operated, the sighting piece 25 is manually rotated in azimuth about the shaft 61 in a clockwise direction and about the shaft 63 in elevation in a clockwise direction in bringing it to bear on a target, the contacts carried by the contact elements 67 and 74 are engaged, the contacts carried by the contact elements 79 and 86 are moved into engagement, and the light beam projected along the line of sight of the sighting piece is shifted so that it no longer cuts the two exploring bands 26 and 27. Incident to these operations, the operating circuit for the relay 140 is prepared at the contacts carried by the two elements 67 and 74, the operating circuit for the relay 170 is prepared at the contacts carried by the two elements 79 and 86, the current traversing the right winding of the relay 100 is decreased until it equals that flowing through the left winding of this relay, and the current traversing the left winding of the relay 110 is decreased until it equals that flowing through the right winding of this relay. Thus the two relays 100 and 110 are caused to restore or deenergize the relays 120 and 130, respectively. The relay 120, in releasing, closes its contacts 121 to complete the prepared circuit through the contact elements 74 and 67 and the contacts 151 for energizing the relay 140. The relay 130, in releasing, closes its contacts 131 to complete a circuit through the contact elements 86 and 79 and the contacts 162 for energizing the relay 170.

The relay 140, upon operating, locks to ground through the contacts 141 and 121 and, at its contacts 142, opens a point in the operating circuit for the relay 150, thereby to prevent the latter relay from being energized until the relay 140 is deenergized. At its contacts 143, the relay 140

completes an obvious circuit for energizing the motor 18. The relay 170, upon operating, locks to ground through the contacts 172 and 131 and, at its contacts 171, opens a point in the operating circuit for the relay 160, thereby to prevent the latter relay from being energized until the operated relay 170 is deenergized. At its contacts 173, the relay 170 closes an obvious circuit for energizing the motor 22.

With the motors 18 and 22 operating, the gun barrel 10 is rotated with the shaft 11 to increase the angle of elevation thereof and the pedestal 12 is rotated to swing the gun barrel in a clockwise direction. Thus the gun 10 is moved in a direction tending to bring it back into parallelism with the line of sight of the sighting piece 25. Incident to the operation of the motor 18, the exploring band 26 is, through the driving connection comprising the flexible shaft 42, the worm 40, the worm gear 39, and the shaft 37, rotated in a direction to increase the angle of elevation thereof, it being again noted that this driving connection serves to maintain the same angle of elevation for the exploring band 26 and the gun barrel 10. Incident to the operation of the motor 22 to drive the pedestal 12 in a clockwise direction, the direction finding band 27 is, through the action of the driving connection comprising the flexible shaft 47, the worm 45 and the worm gear 44, rotated in a clockwise direction about the pedestal 31. In this case, also, the gun barrel 10 and the band 27 are rotated at the same speeds to maintain a parallel relationship between the vertical planes cutting these two elements.

When the elevation finding band 26 is moved to a position where it cuts the light beam projected along the line of sight of the sighting piece 25, the relay 100 is again caused to operate in a manner clearly apparent from the above explanation. This relay, in operating, again closes its contacts 101 to energize the relay 120 and the latter relay, upon operating, opens its contacts 121 to deenergize the relay 140. The relay 140, upon restoring, opens its contacts 143 to deenergize the motor 18 and thus arrest the movements of the exploring band 26 and the gun barrel 10 in the vertical direction. At its contacts 142, the relay 140 reprepares the operating circuit for the relay 150. At its contacts 141, the relay 140 opens its own locking circuit.

When the direction finding band 27 is moved to cut the light beam projected along the line of sight of the sighting piece 25, the relay 110 is caused to reoperate in a manner clearly apparent from the preceding explanation. In operating, this relay closes its contacts 111 to energize the relay 130. The latter relay, upon operating, opens its contacts 131 to deenergize the relay 170. When the relay 170 restores, it opens its contacts 173 to deenergize the motor 22 and thus arrest the horizontal movements of the gun barrel 10 and the exploring band 27. At its contacts 172, the relay 170 opens another point in its own locking circuit. At its contacts 171, the relay 170 reprepares the operating circuit for the relay 160. Following the operations just described the gun barrel 10 is pointing in the direction established by the line of sight of the sighting piece 25, in readiness for firing. A suitable fire control circuit connecting the illustrated control equipment with the electromagnetically controlled firing mechanism of the gun, may be utilized to effect the firing operation. In this regard it will be understood that the operator of the control

11

equipment, upon observing that movement of the two exploring bands 26 and 27 has stopped, is informed that the gun barrel 10 has been brought to bear on the target selected by aiming the sighting piece 25 and, hence, that the firing operation may be started.

To consider another example of the manner in which the control equipment may be operated, it may be assumed that the sighting piece 25 is rotated about the shaft 63 in a direction to decrease the angle of elevation thereof and counterclockwise about the shaft 61 to swing the muzzle of the sighting piece to the left. In response to this operation, the contacts carried by the two contact elements 68 and 74 are engaged, the contacts carried by the two contact elements 86 and 80 are engaged, and the two relays 120 and 130 are deenergized, all in a manner clearly apparent from the preceding explanation. Incident to these operations, a circuit is completed through the contacts 121, the contact elements 74 and 68, and the contacts 142 for energizing the relay 150. Concurrently therewith, a circuit is completed through the contacts 131, the contact elements 86 and 80 and the contacts 171 for energizing the relay 160. The relay 150, upon operating, locks to ground through the contacts 152 and 121; opens its contacts 151 to interrupt the operating circuit for the relay 140; and closes its contacts 153 to energize the driving motor 19 in an obvious circuit. The relay 160, upon operating, locks to ground through the contacts 161 and 131; opens its contacts 162 to interrupt an incomplete operating circuit for the relay 170; and closes its contacts 163 to energize the driving motor 21. With the two motors 19 and 21 operating, the muzzle of the gun barrel 10 is moved to the left and downward from its previous setting, and this movement is accompanied by corresponding changes in the positions of the two exploring bands 26 and 27. When these two bands have been re-positioned under the control of the two motors 19 and 21 so that they again cut the light beam transmitted along the newly established line of sight of the sighting piece 25, the two relays 100 and 110 reoperate to cause the reoperation of the relays 120 and 130. The two relays 120 and 130 respectively function to deenergize the two operated relays 150 and 160. The relay 150, upon restoring, opens its contacts 153 to deenergize the driving motor 19, whereby movement of the exploring band 26 and movement of the gun barrel 10 in the vertical direction is arrested. At its contacts 152, the relay 150 opens another point in its own locking circuit. At its contacts 151, the relay 150 prepares the operating circuit for the relay 140. The relay 160, upon restoring, opens its contacts 163 to deenergize the motor 21, whereby movement of the exploring band 27 and movement of the gun barrel 10 in the horizontal direction are arrested. At its contacts 162, the relay 160 reprepares the operating circuit for the relay 170. At its contacts 161, the relay 160 opens another point in its own locking circuit. Following the operations just described the gun barrel 10 is pointing in the direction established by the line of sight of the sighting piece 25.

From the above explanation it will be understood that the four motors 18, 19, 21 and 22 may be energized in different combinations under the control of the four relays 140, 150, 160 and 170 to drive the gun barrel 10 and the two exploring bands 26 and 27 toward any new position established by movement of the sighting

12

piece 25 to a new setting. For example, if the muzzle of this sighting piece is swung upward and to the left, the two relays 140 and 160 are energized to cause the operation of the two motors 18 and 21, whereby the two exploring bands and the gun barrel 10 are operated to follow the movement of the sighting piece. On the other hand, if the muzzle of the sighting piece is moved downward and to the right, the relays 150 and 170 are energized to cause the operation of the two motors 19 and 22 and the consequent movement of the two exploring bands and the gun barrel 10 to the new position established by the sighting piece. It is also possible with the illustrated arrangement that only one of the four motors may be energized in response to a given change in the setting of the sighting piece 25. Thus if the muzzle of this piece is swung to the left without in any way altering the angle of elevation thereof, the two relays 140 and 150 remain deenergized to prevent the operation of the two motors 18 and 19 and only the relay 160 is energized to effect the operation of the motor 21.

The purpose of providing the described locking circuits for the four relays 140, 150, 160 and 170, is to permit small final adjustments of the sighting piece 25 without disturbing the operation of the energized driving motor or motors to move the gun barrel 10 and the two exploring bands in the general direction required to establish settings for these elements which correspond to the final setting of the sighting piece. In this regard it will be understood that if the sighting piece is pivoted back and forth about the axis of the shaft 63, the contact carried by the contact element 74 is alternately moved to engage the contacts carried by the contact elements 67 and 68. This type of movement of the sighting piece may well be required during the final adjustment of the piece to a new setting. In the absence of the described locking circuits, however, the one of the two motors 18 and 19 energized during the initial movement of the sighting piece to its new setting could be broken during final adjustment of the sighting piece to prematurely stop the movement of the exploring band 26 and the gun barrel 10 in the vertical direction. This difficulty is obviated by providing the described locking circuits for by-passing the contact elements 67, 68, and 74.

The described cut-off contacts 142, 151, 162, and 171 of the relays 140, 150, 160 and 170 are provided to prevent simultaneous energization of the two motors 18 and 19 or simultaneous energization of the two motors 21 and 22. In the absence of these contacts it would be possible, during the final adjustment of the sighting piece 25 to a new setting and the consequent alternate engagement of the contact element 74, for example, with the two contact elements 67 and 68, to establish circuits for energizing both of the relays 140 and 150. In such case both of the motors 18 and 19 would be energized to arrest the movement of the gun barrel 10 and the exploring band 26. By virtue of the described arrangement, however, it is impossible for more than one of the relays 140 and 150, or more than one of the two relays 160 and 170, to be energized at the same time.

The response of the illustrated control equipment is sufficiently fast to insure the energization of the proper driving motors, regardless of the speed at which the sighting piece 25 is shifted from one setting to a different setting. Thus

the sighting piece may be tilted in the direction required to cause the operation of the two relays 140 and 160 and the two motors 18 and 21, and immediately thereafter the direction of movement thereof may be reversed so that the light beam projected along the line of sight of the sighting piece only momentarily cuts the two exploring bands 26 and 27 during the reverse movement of the sighting piece. In such case the two relays 120 and 130 are momentarily operated to cause the deenergization and release of the two relays 140 and 160 and consequent deenergization of the two motors 18 and 21 during the short time interval that the light beam cuts the two exploring bands during the reverse movement of the sighting piece. Immediately thereafter, the two relays 120 and 130 are deenergized and restore to establish circuits for energizing the other two relays 150 and 170 with a consequent energization of the two other driving motors 19 and 22, whereby the direction of movement of the gun barrel 10 and the two exploring bands is reversed to follow the reverse movement of the sighting piece. It will be noted that the terms "exploring band" and "exploring means" as used in the foregoing description and in the claims are intended to refer to a device, such as one of the bands 26 or 27, which has primarily a follow-up function in that it follows the movements of another member such as the gun. This exploring band may be a light sensitive device and have circuit controlling functions as set forth in certain of the claims.

While one embodiment of the invention has been disclosed, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed is:

1. In apparatus for sighting a gun, exploring means, a sighting piece adapted to be brought to bear on a target, means for moving said exploring means and said gun in unison until said gun is brought to a position wherein its line of sight is parallel to the line of sight of said sighting piece, and means controlled by the coincidence of the line of sight of said sighting piece upon a part of said exploring means for arresting the movement of said gun when its line of sight is brought into said parallel relationship.

2. In apparatus for sighting a gun, exploring means, a sighting piece adapted to be moved to a position wherein it bears on a target, means responsive to the movement of said sighting piece for moving said gun in a direction to bring it to a position wherein its line of sight is parallel to the line of sight of said sighting piece, means for moving said exploring means in unison with said gun, and means controlled by the coincidence of the line of sight of said sighting piece upon a part of said exploring means for arresting the movement of said gun when its line of sight is brought into said parallel relationship.

3. In apparatus for sighting a gun, a movable sighting piece adapted to be brought to bear on a target, exploring means normally positioned in coincidence with the line of sight of said sighting piece, driving means for operating said gun in any direction and for operating said exploring means in unison with the operation of said gun, means for initiating the operation of said driving means to operate said exploring means toward a position of coincidence with a newly established line of sight of said sighting piece, and means for automatically arresting the operation of said driving means when said exploring means is

moved to a position of coincidence with the newly established line of sight of said sighting piece.

4. In apparatus for sighting a gun, a sighting piece adapted to be brought to bear on a target, exploring means normally positioned in coincidence with the line of sight of said sighting piece, driving means for operating said gun and said exploring means in unison, means responsive to movement of said sighting piece for selectively controlling said driving means so that said exploring means is moved toward a position of coincidence with the new line of sight of said sighting piece, and means operative to arrest the operation of said driving means when said exploring means attains a position of coincidence with the new line of sight of said sighting piece.

5. In apparatus for sighting a gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, movable light sensitive exploring means adapted to be controlled by said light beam, and means controlled by said exploring means for moving said gun to cause its line of sight to be parallel to the line of sight of said sighting piece.

6. In apparatus for sighting a gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, movable light sensitive exploring means adapted to be energized when moved into said light beam, means for moving said gun and said exploring means in unison, and means responsive to the energization of said exploring means for arresting the movement of said gun.

7. In apparatus for sighting a gun, driving means for changing the traverse and elevation of said gun respectively, exploring means comprising traverse and elevation exploring bands, means controlled by said driving means for operating said bands so that the positions thereof correspond to the traverse and elevation of said gun, a movable sighting piece adapted to be brought to bear on a target, means for starting said driving means, and means controlled by said sighting piece and said bands for stopping said driving means as said exploring bands are respectively operated to intersect the line of sight of said sighting piece.

8. In apparatus for sighting a gun, driving means for changing the traverse and elevation of said gun respectively, exploring means comprising traverse and elevation exploring bands, means controlled by said driving means for operating said bands so that the positions thereof correspond to the traverse and elevation of said gun, a movable sighting piece adapted to be brought to bear on a target, means responsive to movement of said sighting piece from one position to a new position for starting said driving means, and means controlled by said sighting piece and said bands for stopping said driving means as said exploring bands are respectively operated to intersect the line of sight of said sighting piece.

9. In apparatus for sighting a gun, driving means for changing the traverse and elevation of said gun respectively, exploring means comprising light sensitive traverse and elevation exploring bands, means controlled by said driving means for operating said bands so that the positions thereof correspond to the traverse and elevation of said gun respectively, a movable sighting piece adapted to be brought to bear on a tar-

15

get and including means for projecting a light beam along the line of sight thereof, means for starting said driving means, and means controlled by said bands for stopping said driving means as said bands are respectively operated to intersect said light beam.

10. In apparatus for sighting a gun, driving means for changing the traverse and elevation of said gun respectively, exploring means comprising light sensitive traverse and elevation exploring bands, means controlled by said driving means for operating said bands so that the positions thereof correspond to the traverse and elevation of said gun respectively, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, means responsive to movement of said sighting piece from one position to a new position for starting said driving means, and means controlled by said bands for stopping said driving means as said bands are respectively operated to intersect said light beam.

11. In apparatus for sighting a gun, driving means for changing the position of said gun, a light sensitive exploring band having a resistance which changes in accordance with light intensity, means controlled by said driving means for operating said band so that the position thereof corresponds to the position of said gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, means for starting said driving means, whereby said exploring band is operated to intersect said light beam, and means responsive to the resulting change in resistance of said band for stopping said driving means.

12. In apparatus for sighting a gun, driving means for changing the position of said gun, a light sensitive exploring band having a resistance which changes in accordance with light intensity, means controlled by said driving means for operating said band so that the position thereof corresponds to the position of said gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, means responsive to movement of said sighting piece from one position to a new position for starting said driving means, whereby said exploring band is operated to intersect said light beam, and means responsive to the resulting change in resistance of said band for stopping said driving means.

13. In apparatus for sighting a gun, driving means for changing the position of said gun, a light sensitive exploring band having a resistance which changes in accordance with light intensity, means controlled by said driving means for operating said band so that the position thereof corresponds to the position of said gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, means for starting said driving means, whereby said exploring band is operated to intersect said light beam, means responsive to the resulting change in resistance of said band for stopping said driving means, and means for preventing said last-named means for responding to changes in the resistance of said exploring band which result from changes in the temperature of said band and changes in the ambient light conditions surrounding said band.

14. In apparatus for sighting a gun, driving

16

means for changing the position of said gun, a light sensitive exploring band having a resistance which changes in accordance with light intensity, means controlled by said driving means for operating said band so that the position thereof corresponds to the position of said gun, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a light beam along the line of sight thereof, means responsive to movement of said sighting piece from one position to a new position for starting said driving means, whereby said exploring band is operated to intersect said light beam, means responsive to the resulting change in resistance of said band for stopping said driving means, and means for preventing said last-named means from responding to changes in the resistance of said exploring band which result from changes in the temperature of said band and changes in the ambient light conditions surrounding said band.

15. In apparatus for sighting a gun, driving means for changing the position of said gun, a light sensitive exploring element having a resistance which changes with light intensity, means controlled by said driving means for operating said element so that the position thereof corresponds to the position of said gun, a light sensitive balancing element having substantially the same characteristics as said exploring element, a relay comprising a pair of differentially related windings, means for controlling the energization of one of said windings in accordance with the resistance of said exploring element, means for controlling the energization of the other of said windings in accordance with the resistance of said balancing element, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a beam of light along the line of sight thereof, means for starting said driving means, whereby said exploring band is operated to intersect said light beam, the change in resistance of said exploring element resulting from the intersection of said beam by said exploring element being effective to cause the operation of said relay, and means responsive to the operation of said relay for stopping said driving means.

16. In apparatus for sighting a gun, driving means for changing the position of said gun, a light sensitive exploring element having a resistance which changes with light intensity, means controlled by said driving means for operating said element so that the position thereof corresponds to the position of said gun, a light sensitive balancing element having substantially the same characteristics as said exploring element, a relay comprising a pair of differentially related windings, means for controlling the energization of one of said windings in accordance with the resistance of said exploring element, means for controlling the energization of the other of said windings in accordance with the resistance of said balancing element, a movable sighting piece adapted to be brought to bear on a target and including means for projecting a beam of light along the line of sight thereof, means responsive to movement of said sighting piece from one position to a new position for starting said driving means, whereby said exploring band is operated to intersect said light beam, the change in resistance of said exploring element resulting from the intersection of said beam by said exploring element being effective to cause the operation of

said relay, and means responsive to the operation of said relay for stopping said driving means.

WM. WALTER OWEN,

Executor of the Estate of Bernard D. Willis,
Deceased.

Number
1,747,664
1,957,240
2,034,223

5

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
407,487	Maxim	July 23, 1889

Number
28,711
422,009
473,067
482,325
304,230
789,778

10

Name	Date
Droitcour	Feb. 18, 1930
Young	May 1, 1934
Brady	Mar. 17, 1936

FOREIGN PATENTS

Country	Date
Great Britain	1911
Great Britain	Jan. 3, 1935
Great Britain	Oct. 6, 1937
Great Britain	Mar. 28, 1938
Germany	Jan. 27, 1920
France	Aug. 26, 1935